Li-ION BATTERY ENERGY STORAGE SYSTEM (BESS)

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Project Resources: Knowledge and ETAP software from Burns & McDonnell. Microsoft and Autodesk software package from Iowa State University. Team members used personal computers for all aspects of project.

Motivation: The Li-Ion BESS was designed as a conceptual project to provide backup power capabilities to Iowa State University in cases of blackout. The BESS will provide backup power capabilities for 2 hours. The BESS would be charged from excess solar power produced around campus.
Intended Users: Iowa State University and anyone else connected to the ISU grid (which is separate from the Ames power grid)
Standards: NFPA 70 Article 250, NFPA Atricle 706, IEEE 80 AC Substation Grounding, IEEE 3002.2 Load Flow Studies, IEEE 3002.3 Short Circuit Studies

Design Approach, Figure 1: Site Layout

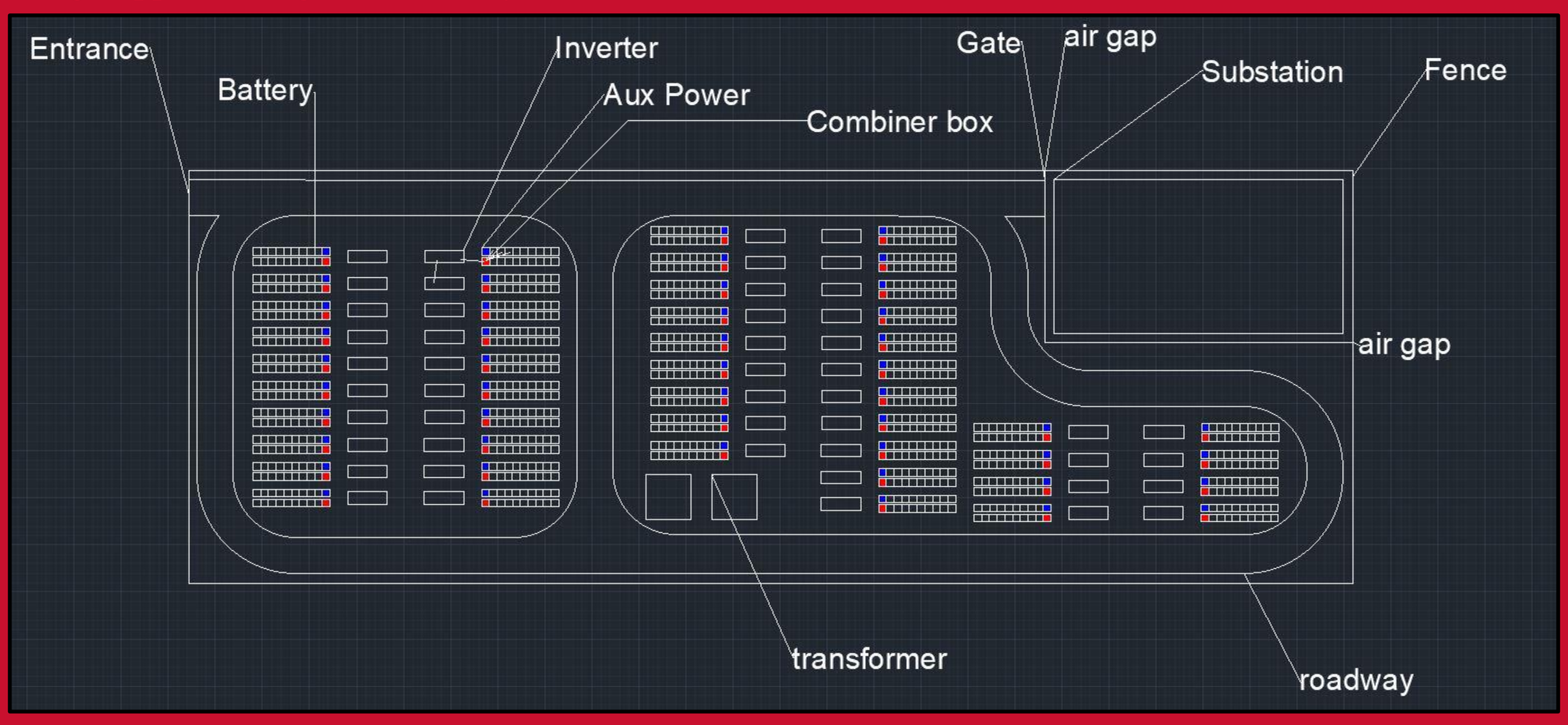

Figure 1:

- Shows the position relative to the location of all components.
- Sets up future design documents like: the One Line, Grounding Plan, and load and short-circuit analysis.

Technical Details, Figure 2: One-Line Diagram

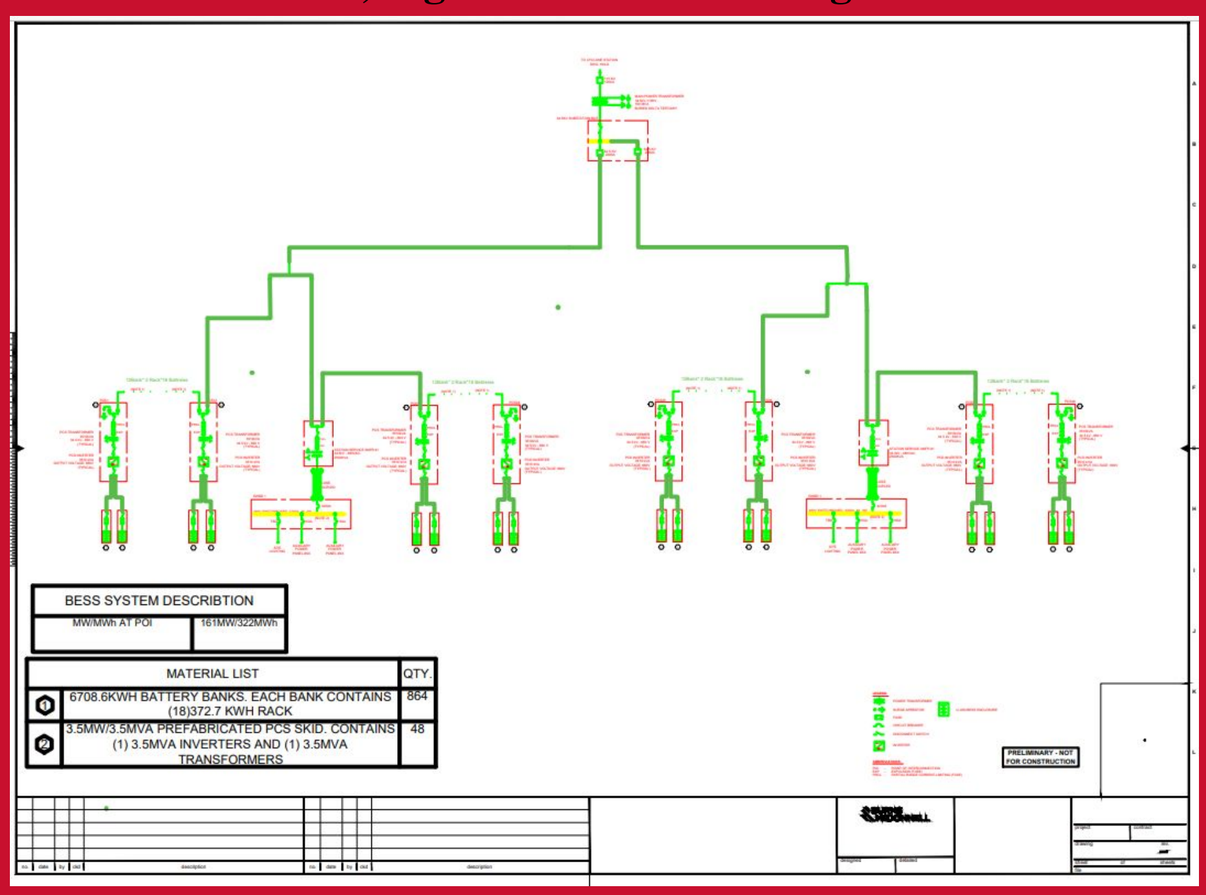

Figure 3:
Testing Strategy/Testing Environment , Load Flow analysis in ETAP: Ths one section of four our system consists of.

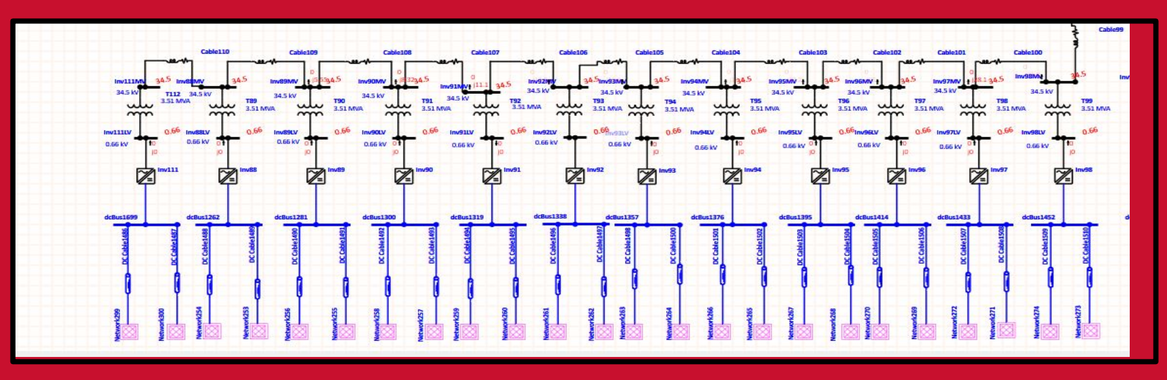

Figure 4:
Testing Environment, Short Circuit AC in ETAP:
One of four sections our system consists of.

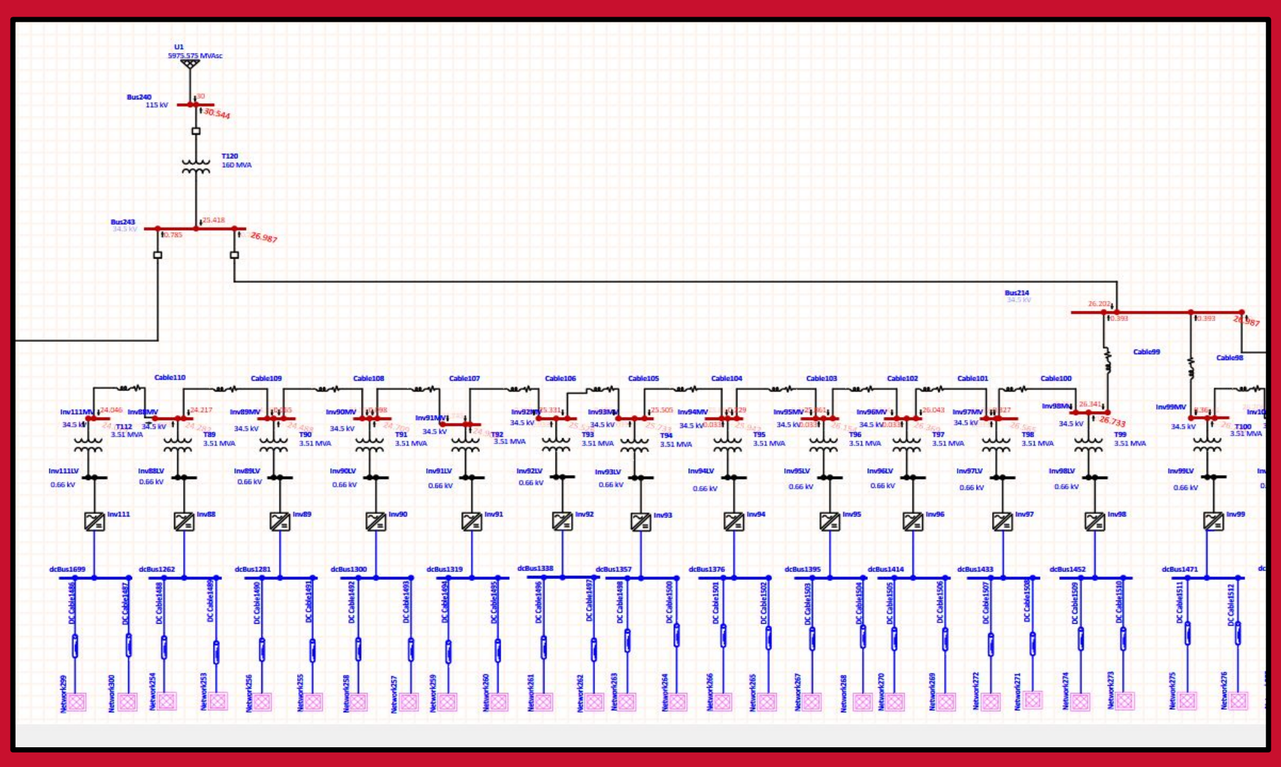

Figure 2

- A representation of a 3-phase system using one line.
- It is compiled of battery racks, inverters, transformers, and a substation.
- The heart of the project.

Technical Details, Figure 5: Wire Diagram

Cable Number	From Tag	From Description	To Tag	To Description	Cable Desc	Cable Type
Battery Banks to Combiner box and Auxiliary Power Cabinets						
BB1.1-CB1	CB1	Combiner box 1 DC	BB1.1	Battery Bank 1.1	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.1-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.1	Battery Bank 1.1	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.2-CB1	CB1	Combiner box 1 DC	BB1.2	Battery Bank 1.2	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.2-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.2	Battery Bank 1.2	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.3-CB1	CB1	Combiner box 1 DC	BB1.3	Battery Bank 1.3	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.3-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.3	Battery Bank 1.3	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.4-CB1	CB1	Combiner box 1 DC	BB1.4	Battery Bank 1.4	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.4-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.4	Battery Bank 1.4	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.5-CB1	CB1	Combiner box 1 DC	BB1.5	Battery Bank 1.5	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.5-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.5	Battery Bank 1.5	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.6-CB1	CB1	Combiner box 1 DC	BB1.6	Battery Bank 1.6	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.6-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.6	Battery Bank 1.6	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.7-CB1	CB1	Combiner box 1 DC	BB1.7	Battery Bank 1.7	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.7-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.7	Battery Bank 1.7	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.8-CB1	CB1	Combiner box 1 DC	BB1.8	Battery Bank 1.8	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.8-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.8	Battery Bank 1.8	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.9-CB1	CB1	Combiner box 1 DC	BB1.9	Battery Bank 1.9	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.9-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.9	Battery Bank 1.9	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.10-CB1	CB1	Combiner box 1 DC	BB1.10	Battery Bank 1.10	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.10-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.10	Battery Bank 1.10	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.11-CB1	CB1	Combiner box 1 DC	BB1.11	Battery Bank 1.11	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.11-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.11	Battery Bank 1.11	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.12-CB1	CB1	Combiner box 1 DC	BB1.12	Battery Bank 1.12	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.12-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.12	Battery Bank 1.12	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.13-CB1	CB1	Combiner box 1 DC	BB1.13	Battery Bank 1.13	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.13-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.13	Battery Bank 1.13	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.14-CB1	CB1	Combiner box 1 DC	BB1.14	Battery Bank 1.14	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.14-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.14	Battery Bank 1.14	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.15-CB1	CB1	Combiner box 1 DC	BB1.15	Battery Bank 1.15	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.15-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.15	Battery Bank 1.15	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.16-CB1	CB1	Combiner box 1 DC	BB1.16	Battery Bank 1.16	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.16-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.16	Battery Bank 1.16	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.17-CB1	CB1	Combiner box 1 DC	BB1.17	Battery Bank 1.17	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.17-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.17	Battery Bank 1.17	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.18-CB1	CB1	Combiner box 1 DC	BB1.18	Battery Bank 1.18	HEN 5,000-Volt	2-1/C #2/0AWG
BB1.18-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.18	Battery Bank 1.18	SEN 600-Volt	1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
CB1-PCS1	CB1	Combiner box 1 DC	PCS1	Inverter 1	HEN 5,000-Volt	16-1/C 750 kcmil
AP1-PCS1CAT	AP1	Auxiliary Power Cabinet 1 AC	PCS1	Inverter 1	COMMUNICATION	1-4PRCAT6-SHIELDED

Figure 5:

- A document of how the BESS is wired together with AC, DC and communication cables.
- Cables sizes were determined based on voltage and current flow.

Design Approach, Figure 6: Grounding Plan

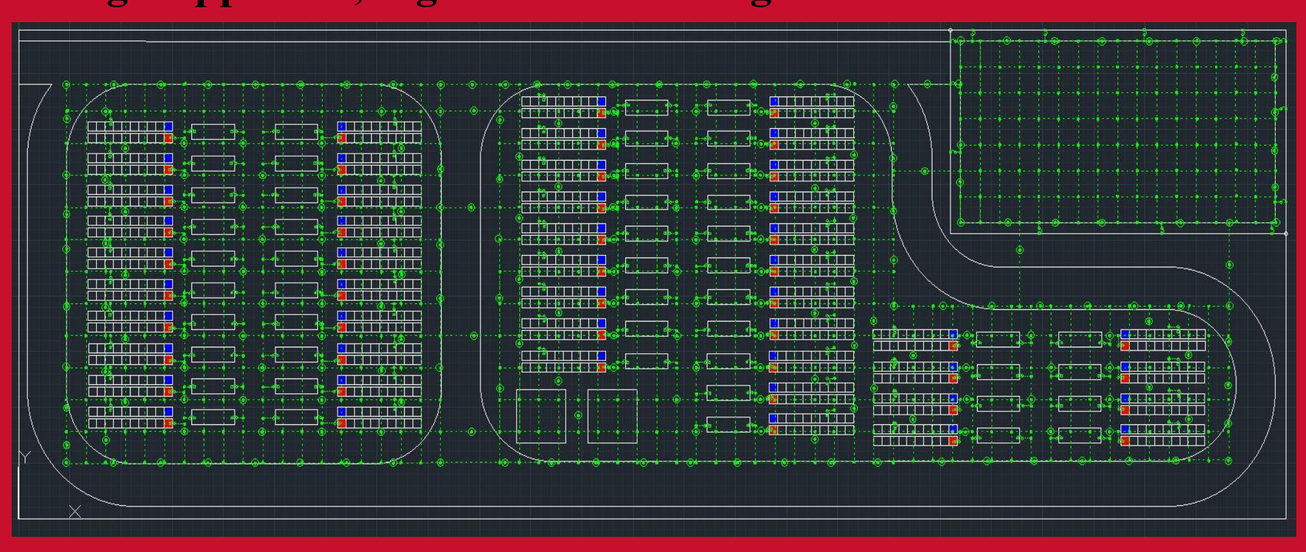

Figure 6:

- Uses IEEE and NEC 2020 Code to construct grounding layout.
- Provides a grounding network of bare Cu to prevent touch and step potentials as well as mitigate fault or short circuit disturbances.